Chapter Two

Highways

Deteriorating roads and increasing traffic congestion are often cited as being detrimental to our nation's quality of life and impediments to its productivity. The Federal Highway Administration (FHWA) reports that

> Highways in poor condition cost users as much as 25 to 30 percent more per mile than highways in good condition. Highly congested peak-period travel . . . can add as much as 35 percent to the unit operating and time costs of a commercial vehicle. Every 1 percent increase in highway user costs adds about $15 billion to the Nation's total highway bill . . . .[1]

How can these problems be alleviated in an environment of tight budgets at all levels of government? What can be done at the federal level? For one thing, user charges could provide incentives for more efficient use of the nation's highways. More efficient use of roadways can enhance their productivity and prolong their life, thereby reducing the need for additional investments.

Highways are financed primarily through taxes on fuels, vehicles, and equipment used by motorists. Although this arrangement adheres to the principle that users of roads should pay for them, current taxes provide little or no incentive for efficient use of highways. The taxes paid by different kinds of highway users--automobiles and trucks, in urban and rural areas--correlate only roughly to the costs imposed by different groups. For example, an automobile driven at rush hour in a major city incurs the same federal fuel tax as one driven on an uncongested rural highway (assuming they use the same amount of fuel per mile). But the automobile driven in heavy traffic imposes congestion costs on other motorists and may--depending on the ambient air quality--add significantly to environmental pollution.

The fact that existing taxes do not correlate well with costs has led planners to seek taxes or charges that do. Researchers have made progress recently in finding practical alternative mechanisms for pricing. One proposal that has received considerable attention is a fee based on distance driven and weight supported by each axle of a vehicle. This approach would better represent the cost of pavement damage and encourage operators of heavy trucks--which do a disproportionate amount of damage to pavement--to spread the weight over more axles and thus reduce road damage. A fee or toll reflecting the costs of delay of an additional vehicle on a congested highway could help alleviate congestion by inducing some motorists to shift to less congested times or places, or to another mode of transport. A fee that also reflected pollution costs would provide incentives to reduce vehicle emissions.

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1. *The Status of the Nation's Highways and Bridges: Conditions and Performance*, Report of the Secretary of Transportation to the United States Congress pursuant to Sections 307(e) and 144(i) of Title 23, U.S. Code (September 1991), pp. 4-5.

The principle of designing efficient charges for congestion, weight, distance, and pollution is well developed: set the price equal to marginal social cost. Analysts have made rough estimates of the marginal social costs of these factors, although additional research to update and refine the estimates--especially of emissions costs--would be desirable. Efficient pricing could raise enough revenue to reduce or eliminate existing taxes.

Background

The federal government collects and distributes funds for highways. In 1990, it disbursed about $15 billion in grants to states from federal taxes levied on highway users. State and local governments raised and spent another $60 billion on roads, for a total of about $75 billion.[2]

Although the federal government's share of highway finance is just one-fifth of the total, it plays an important role in highway policy, for several reasons. First, the absolute amount of money spent on highways is quite large. Second, the federal government attaches conditions to its financial aid. It allocates money to projects and requires the states to contribute matching funds. It also sets standards and rules governing the construction and operation of highways built with federal aid. Policies affecting highways built with federal aid often affect local streets and roads as well. Finally, the federal government provides technical assistance, research and development, and leadership in trying new solutions to the many problems confronting state and local highway officials.

2. Department of Transportation, Federal Highway Administration, *Highway Statistics 1990*, Table HF-10, p. 42. The last year for which final state data and estimates of local data are available is 1990.

In the debate over the 1991 reauthorization of the federal-aid highway program, the principal concerns were how to allocate federal aid among the states and how to design the program--the types of highways to receive federal aid, how the federal government and the states would share the costs, and the conditions that the federal government attached to aid to the states. Less attention was paid to pricing. But the Congress recognized that the scarce resources available for highways must be used ever more productively. The result was provisions for toll roads, experimentation with congestion pricing, and increased funding for research. Technological advances from research on intelligent vehicle/highway systems (IVHS) are expected to provide opportunities for new pricing mechanisms that promote more efficient use of the highway system, alleviate congestion, and indicate where additions to capacity are needed most.

The federal government can affect incentives for efficiency through its choice of financing mechanisms, such as taxes on motor fuels and heavy trucks and equipment, fees based on vehicle weight and distance driven, and fees reflecting costs of congestion and pollution, and through the regulations it imposes on states as a condition of federal aid. Restrictions on the ability of the states to impose tolls, for instance, can dramatically affect efficiency as well as financing ability.

Since state and local governments finance and control policies over most of the nation's roadways, the federal government influences highway efficiency indirectly. Even when the federal government pays most of the cost of a road, it turns ownership and management over to the state and local governments. But the federal government can assist the states in several ways. It can encourage efficiency, especially where it provides money with strings attached; coordinate policies and resolve conflicts among states; provide leadership in developing and putting into effect new ways to improve efficiency; and refrain from inhibiting state and local efforts to promote efficiency, especially when the effects are felt primarily at the state or local level.

Federal Spending on Highways

In 1991, the federal government obligated $16.3 billion for highway programs. Most of the money was for grants to states. States match these funds to build new highways and bridges and make major improvements to existing ones. The federal government pays from 75 percent to 90 percent of the cost and the state pays from 10 percent to 25 percent for projects that comply with federal requirements.[3] The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) provides a federal share for most projects of up to 80 percent. For Interstate Highway construction, the federal share is 90 percent, and for construction or expansion of facilities primarily for single-occupant vehicles, the maximum federal share is 75 percent. Before the 1991 act was passed, the federal government's share was generally as follows: Interstate Highway System and safety construction projects, 90 percent; bridge projects, 80 percent; most other projects, 75 percent. States with large tracts of federal land may receive a larger proportion of federal aid.

The federal government distributes highway funds to the states on the basis of formulas prescribed by law. The formulas are based on such factors as miles of highway, area, rural and urban population, and vehicle-miles traveled.[4] Each state is guaranteed a minimum share of funding based on its estimated contributions to the Highway Trust Fund.

The federal government attaches conditions to its aid to force states to comply with national policies. For instance, the federal government withholds funds from states that allow trucks heavier than those permitted under federal law. States must spend at least 10 percent of the amount authorized for highways on purchases from small businesses owned and controlled by socially and economically disadvantaged individuals. States also must comply with "Buy America" provisions.

In the past, the federal government generally prohibited states from charging tolls on roads built with federal aid. The rationale for this prohibition, which dates back to the original Federal Aid Act of 1916, was that free and open highways stimulate economic growth and development. But as early as 1927, the Congress allowed exceptions to this policy, recognizing that toll financing would enable additions to highway capacity sooner than would otherwise be possible. Section 1012 of the Intermodal Surface Transportation Efficiency Act of 1991 allows the federal government to pay up to 50 percent of the cost of toll highways, bridges, and tunnels. It also permits a federal share of up to 80 percent of the cost of rehabilitating existing toll facilities or converting existing free facilities to toll facilities. Section 1008 of ISTEA establishes a program to ease congestion and improve air quality. Together these policies could help improve traffic management, alleviate congestion and pollution, and encourage more productive use of the existing highway system.

Current Financing Policy

Federal highway spending is financed by taxes paid by highway users. Excise taxes on gasoline, diesel fuel, and other fuels are the largest source of revenue; in 1991, they brought in about $15.5 billion, or 89 percent of revenues from taxes on highway users. Excise taxes on heavy trucks and trailers generated $1.0 billion, or 6 percent of revenues, in 1991.

3. For a thorough explanation of how the federal aid program works, see Department of Transportation, Federal Highway Administration (Legislation and Strategic Planning Division), *Financing Federal-Aid Highways*. This volume was last published in November 1987 but is being revised to reflect the ISTEA of 1991.

4. For apportionment formulas, minimum allocations, and their underlying statutory authority, see Department of Transportation, *Financing Federal-Aid Highways*, Appendix C-1, pp. 54-56.

Taxes on tires and heavy vehicles accounted for the remaining 5 percent.

Revenues increased by about $3.5 billion in 1991 as a result of increases of 5 cents a gallon in tax rates on most motor fuels provided under the Omnibus Budget Reconciliation Act of 1990 (OBRA). The tax rates on motor fuels before and after the passage of OBRA are shown in Table 1. Most of the revenues from these taxes are deposited in the Highway Trust Fund, from which grants to states are made.[5]

Table 1.
Federal Tax Rates on Motor Fuels Before and After the Omnibus Budget Reconciliation Act of 1990 (OBRA) (In cents per gallon)

	Pre-OBRA[a]	Post-OBRA
Gasoline	9.0	14.0
Diesel Fuel	15.0	20.0
Special Fuels	9.0	14.0
Gasohol[b]	3.0	8.6
Diesohol[c]	9.0	14.6
Ethanol[d]	3.0	8.6
Methanol[e]	3.0	8.6
Fuels from Natural Gas	4.5	7.0

SOURCE: Internal Revenue Code, 26 USC 4081.

NOTE: An additional 0.1 cent a gallon tax is collected and deposited in the Leaking Underground Storage Tank Trust Fund.

a. Tax rates from 1985 through November 30, 1990.

b. Mixture of at least 10 percent ethanol or methanol made from biomass, and 90 percent gasoline.

c. Mixture of diesel and 10 percent alcohol made from biomass.

d. Ethanol containing at least 85 percent alcohol and not derived from petroleum or natural gas.

e. Methanol containing at least 85 percent alcohol and not derived from petroleum or natural gas.

Gasoline and Other Fuel Taxes

The federal gasoline tax is 14 cents a gallon, and the diesel fuel tax is 20 cents a gallon.[6] OBRA raised these taxes by 5 cents a gallon. In addition, OBRA eliminated or reduced favored treatment of other motor fuels, such as gasohol and diesohol. Until 1984, tax rates on gasoline and diesel fuel were the same. The so-called "diesel differential" was enacted into law as part of a compromise that reduced the direct tax on heavy vehicles; it is intended to reflect the fact that trucks do more damage to roads than automobiles.

Proponents of fuel taxes cite several advantages of using them as a source of highway financing:

- They are a lucrative source of revenue at both federal and state levels. Because the demand for fuel is relatively insensitive to small changes in the price, an increase in fuel taxes can be counted on as a revenue-raiser; a penny a gallon generates about $1 billion a year at the federal level.

- The general public seems to accept fuel taxes as a legitimate--and even desirable--way to raise funds for highways.

- Earmarking taxes for the benefit of users generally appeals to the public. Proponents of raising fuel tax rates note that people did not complain much about the 1990 tax increases, even though some of the revenues were to go to the general fund of the U.S. Treasury,

5. Until OBRA was passed, all revenues from fuel taxes were deposited in the Highway Trust Fund with the exception of 0.1 cent a gallon designated for cleanup of leaking underground storage tanks. One cent a gallon went into the transit account of the Highway Trust Fund, which was earmarked for mass transit projects. A provision that 2.5 cents a gallon is to be deposited in the general fund of the U.S. Treasury came with the fuel tax increases of OBRA. The amount designated for the transit account was increased to 1.5 cents a gallon.

6. An additional 0.1 cent a gallon is levied under Title 26, U.S. Code, Section 4091 to pay for cleanup of leaking underground storage tanks.

rather than the Highway Trust Fund, for the first time since the trust fund was established. These tax increases, however, came at a time when fuel price fluctuations resulting from the Persian Gulf turmoil may have been large enough to mask the tax increases at the pump.

o Finally, the mechanisms for collecting the fuel taxes are in place, and increases in tax rates add little to collection and enforcement costs.

As concerns about pollution and energy independence have mounted in recent years, fuel taxes have been proposed as incentives for reducing pollution and conserving energy. If the costs of pollution and energy waste could be determined, imposing fuel taxes reflecting these costs would lead to more economically efficient patterns of use. But a single policy tool, such as fuel taxes, cannot be counted on to achieve multiple policy goals, such as clean air, energy conservation, and highway financing. Therefore, if fuel taxes come to be viewed as a way of discouraging highway use--to promote environmental protection or energy security--the present policy of directing most of the revenues to the highway trust fund should be reexamined.

On the minus side, although fuel taxes are good revenue generators, they do not provide strong incentives for the efficient use of highways. The reason is that they do not correlate closely with actual costs imposed by specific users. Automobiles that get 35 miles to a gallon of gasoline impose about the same pavement and congestion costs as automobiles that get just 20 miles a gallon, assuming similar driving patterns. But the fuel-efficient cars pay far less in gasoline taxes than their gas-guzzling counterparts.

Even more important, fuel taxes do not adequately reflect different pavement damage caused by automobiles and trucks. Pavement damage rises rapidly as the weight borne by each axle increases. Although heavier trucks consume more fuel and therefore incur more fuel tax, pavement costs rise more rapidly with weight than do fuel tax revenues. For example, according to the American Association of State Highway and Transportation Officials (AASHTO), an 80,000-pound truck typically does twice as much damage per mile as a 50,000-pound truck, but uses only 14 percent more fuel.[7] The diesel differential of 6 cents a gallon does not pay for the damage done by trucks with heavy axle weights, but it overcharges light trucks and trucks that distribute their weight over more axles.

Vehicles incur approximately the same fuel taxes per mile regardless of whether they are driven on empty or congested roads. Although stop-and-go driving on congested roads diminishes fuel economy, it does not result in enough of an increase in fuel taxes to reflect the social costs of congestion, discourage use during peak hours, or signal the need for future investment.

Some states have developed tax structures based on vehicle weight and distance traveled.

Excise Tax on Trucks and Trailers

With certain exceptions, there is a 12 percent excise tax on the retail price of trucks and trailers. This tax raises relatively little revenue compared with fuel taxes: slightly more than $1 billion in 1991, or 6 percent of revenues from taxes on highway users. It bears

7. "Oregon Develops New System of Road User Taxation," *AASHTO Quarterly* (January 1991), p. 3.

little relationship to the costs the vehicle may impose on highways, since the price of a vehicle depends more on its special features or outfitting than on its weight. And, of course, the excise tax bears no relationship to mileage. This is critical for piggyback trailers, which travel long distances by rail and relatively short distances on local highways. Since the excise tax is tied to sales price, revenues rise with inflation. Although this characteristic neither adds to nor detracts from the efficiency of the tax, it provides an interesting contrast to fuel taxes, which are based on the physical unit of gallons and are not tied to inflation.

Heavy Vehicle Use Tax

The heavy vehicle use tax (HVUT) is an annual tax on heavy motor vehicles. For vehicles with gross weights of 55,000 to 75,000 pounds, the tax is $100 plus $22 per 1,000 pounds over 55,000 pounds; for vehicles with gross weights over 75,000 pounds, the tax is $550.[8] This tax generated $575 million, or 3 percent of highway tax revenues, in 1991.

The HVUT is intended as a method of charging heavy motor vehicles for the pavement damage they cause. But it is levied on an annual basis, without regard to how many miles the truck is driven or how much weight it carries. Since the tax is based on registered gross vehicle weight, it roughly reflects how heavy a truck's loads are likely to be--and therefore how much damage the vehicle would cause to pavement--but does not make allowance for the fact that some vehicles run more miles than others in empty backhauls. Although the HVUT generally varies in the same direction as highway damage, it does not increase with weight as rapidly as highway damage does. Nor does it account for differences in vehicle configuration, although spreading the same weight over more axles reduces pavement damage.

Excise Tax on Tires

New tires are taxed at 15 cents for each pound between 40 and 70, and $4.50 plus 30 cents for each pound between 70 and 90. Tires heavier than 90 pounds are taxed at $10.50 plus 50 cents for each pound over 90 pounds. Retread tires are not subject to this tax. The tax on tires generated about $357 million, or about 2 percent of revenues from highway sources, in 1991.

Since tires wear out with use, the tire tax varies with mileage and, to a lesser extent, with weight of load, and thus correlates with pavement wear. But the tax works perversely, since using additional tires to spread a truck's load over additional axles reduces the damage it does to the pavement. The exemption of retread tires also diminishes the ability of this tax to reflect costs.

Taxes at State and Local Levels

Although the federal government relies on taxes on motor fuels, vehicles, and equipment to finance highways, state and local governments draw upon a wider variety of revenue sources. In 1989 (the most recent year for which local data are available), 18 percent of highway spending financed by state sources came from receipts not related to highways, as did 93.9 percent of local highway spending financed by local sources (see Table 2).

Many of the user-related taxes imposed at the state level parallel those imposed at the federal level. Motor fuel taxes are the largest single highway-related revenue source at both federal and state levels. The structure of state fuel taxes generally follows that of the federal--expressed in cents per gallon--but some states also include an excise tax component that is a percentage of the sales price. If the revenues go to a general fund, the tax should

8. Lower rates apply for certain logging and farm trucks and others that drive relatively few miles on public highways.

not be considered a user tax. Registration fees for trucks are similar at the state and federal levels, as are registration fees for automobiles. Both are levied annually and often based on vehicle weight.

Table 2.
Funding from Own Sources for State and Local Highways, 1989

	Receipts (Thousands of dollars)	Percent
State Receipts from State Sources		
Highway Users		
Motor fuel taxes	11,641,684	45.3
Motor vehicle and carrier taxes	6,959,812	27.1
Tolls	2,500,162	9.7
Subtotal	21,101,658	82.0
General Sources		
General funds	1,455,562	5.7
Other state imposts	1,131,191	4.4
Miscellaneous state receipts	2,035,817	7.9
Subtotal	4,622,570	18.0
Total	25,724,228	100.0
Local Government Receipts from Local Sources		
Highway Users		
Local highway user revenue	837,057	4.3
Tolls	355,666	1.8
Subtotal	1,192,723	6.1
General Sources		
Property tax	4,302,805	22.1
General fund[a]	8,502,843	43.6
Miscellaneous	3,418,295	17.5
Bond proceeds	2,093,014	10.7
Subtotal	18,316,957	93.9
Total	19,509,680	100.0

SOURCES: Department of Transportation, Federal Highway Administration, *Highway Statistics 1989*, Table SF-3, p. 73, and *Highway Statistics 1990*, Table LGF-21, p. 106.

a. May include receipts from property taxes when they are commingled with general fund appropriations.

Tolls raised about $2.5 billion at the state level and about $355 million at the local level in 1989. They undoubtedly could have contributed still more to revenues if it had not been for restrictions imposed by the federal government. Tolls are often based on the number of axles for ease of enforcement. This basis provides an incentive to use fewer axles, a perverse incentive, since wear and tear on pavements increases at a disproportionate rate as more weight is loaded on an axle.

Some states have developed tax structures based on vehicle weight and distance traveled. Such taxes can promote efficient use of highways by making users recognize the pavement damage caused by heavy vehicles and creating disincentives to overload trucks.

Costs and Efficient Charges

The foregoing discussion suggests that federal taxes imposed on highway users do not correlate very well with the costs these users impose on highways. Designing efficient charges requires a good understanding of costs, especially marginal costs. Pavement and congestion constitute the two principal types of costs. Environmental costs make up a third category, about which less research has been done.

Pavement Costs

There are two basic approaches to the study of pavement costs. One is a "top-down" cost allocation study, which starts with total federal spending on highways and attempts to allocate it among different classes of users, such as heavy trucks, light trucks, and automobiles. The costs attributable to each class of users are then compared with the revenues generated by the taxes imposed on it. The other approach proceeds from the bottom up; it attempts to estimate the cost associated with each additional unit of use--the marginal cost.

It then compares the marginal cost with the marginal revenue from the taxes paid by users. This study focuses on the latter approach, since the primary concern is marginal-cost pricing. For comparative purposes, two top-down cost-allocation studies are discussed in the Appendix.

Factors Affecting Pavement Costs. What causes pavement to crack and crumble? Vehicles--especially heavy trucks--passing over pavement contribute to its damage and destruction, along with other factors such as weathering. Studies of pavement damage have attempted to sort out these factors and to calculate how much pavement cost to attribute to automobiles and trucks of different weights and configurations.

Cost studies generally find that pavement damage is a function of the weight carried on each axle of a vehicle, although there is some disagreement about the exact relationship between axle weight and damage. Pavement deterioration is also accelerated by adverse weather conditions, such as freezing and thawing. The precise relationship between weather and axle weight is not clear. There may be an interactive relationship in which additional use of vulnerable pavement is especially damaging; alternatively, weather may act independently of use.

Automobiles do very little damage to standard highway pavements. The size of a truck-trailer combination is less important than how much it carries and how the weight is distributed. Carrying a load of 26,000 pounds on two axles instead of three, for example, increases the marginal cost of pavement by a factor of four (see Table 3).

Two studies that have examined marginal costs are Appendix E of the Federal Highway Administration's *Highway Cost Allocation Study (HCAS)*, and *Road Work* by Kenneth A. Small, Clifford Winston, and Carol A. Evans.[9] (See Table 3 for selected common truck types and configurations, estimates of current taxes, and marginal costs of pavement maintenance.) Some configurations, such as three-axle single units with gross weights of 26,000 pounds, and five-axle tractor-semitrailers with gross weights of 33,000 pounds operating in urban areas, pay more in taxes than their marginal costs. Many other kinds of vehicles pay less than their marginal costs.

The authors of both *Road Work* and *HCAS* Appendix E started with the proposition that pavement damage is a function of the weight supported by each axle. Because vehicles come in many shapes and sizes, researchers must choose a standard unit by which they can measure and compare the loads that different vehicles impose on roads. The unit commonly used for this purpose is the amount equivalent to a single 18,000-pound axle load, called an equivalent standard axle load, or ESAL. (For estimates of pavement repair costs per ESAL-mile for different types of roads, see Table 4). The differences between the estimates of *HCAS* Appendix E and *Road Work* are caused by the fact that they use different functional relationships between axle weight and damage.[10] The jury is still out on the correct relationship, and new testing would be desirable if weight per axle were to become the basis for user charges.

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9. Department of Transportation, Federal Highway Administration, *Final Report on the Federal Highway Cost Allocation Study*, Report of the Secretary of Transportation to the United States Congress Pursuant to Public Law 95-599, Surface Transportation Assistance Act of 1978 (May 1982). The main part of the *HCAS* is described in the Appendix. Because Appendix E of the *HCAS* took a different approach from that of the main volume, it is appropriate to distinguish between the two. Kenneth A. Small, Clifford Winston, and Carol A. Evans, *Road Work* (Washington, D.C.: Brookings Institution, 1989).

10. The source of both estimates is an experiment sponsored in the late 1950s by the American Association of State Highway Officials (AASHO), known as the AASHO Road Test. (AASHO has since become AASHTO, the American Association of State Highway and Transportation Officials.) Small and others explain their estimation procedure in the Appendix to Chapter 2 of *Road Work*. *HCAS* used the AASHO road test results, but the authors of *Road Work* took the data from the AASHO road test and reestimated the relationship using different econometric techniques. A critique of the analysis is contained in Michael T. McNerney and W. Ronald Hudson, "An Engineering Analysis of the Economics of Predicted Pavement Life" (paper presented at the 71st Annual Meeting of the Transportation Research Board, Washington, D.C., January 1992).

Pricing to Reflect the Marginal Costs of Pavement Damage. Drawing on their research linking vehicle weight and pavement damage, the authors of the studies discussed above have proposed prices that would reflect marginal costs and thereby promote efficient pavement use. Efficient charges are based on the weight loaded on each axle and on the distance traveled by the vehicle.

In the proposals developed by the authors of *HCAS* Appendix E (see Table 5), there are no charges for pavement damage done by automobiles, since the injury they do to roads is negligible. Efficient charges for pavement damage by trucks range from 5 cents a mile for a nine-axle tractor-semitrailer-trailer with a gross weight of 105,000 pounds on a heavy-duty road such as a highway on the Federal

Table 3.
Comparison of Marginal Cost Responsibility and User Taxes Paid, for Selected Truck Types, 1982
(In 1982 cents per vehicle-mile)

Vehicle Type, Gross Weight	Current Taxes	Marginal Cost[a]	Ratio of Taxes to Marginal Cost[b]
	Urban Travel		
Single Unit			
2-axle 26,000 pounds	2.52	9.16	0.28
3-axle 26,000 pounds	3.88	2.07	1.87
5-Axle Tractor-Semitrailer			
33,000 pounds	4.07	1.20	3.39
55,000 pounds	5.34	9.22	0.58
80,000 pounds	7.19	41.26	0.17
105,000 pounds	8.28	122.44	0.07
5-Axle Tractor-Semitrailer-Trailer			
55,000 pounds	6.01	10.04	0.60
80,000 pounds	7.85	44.92	0.17
	Intercity Travel		
Single Unit			
2-axle 26,000 pounds	1.95	3.21	0.61
3-axle 26,000 pounds	3.25	0.73	4.45
5-Axle Tractor-Semitrailer			
33,000 pounds	3.16	0.42	7.52
55,000 pounds	3.86	3.23	1.20
80,000 pounds	4.96	14.46	0.34
105,000 pounds	5.56	42.91	0.13
5-Axle Tractor-Semitrailer-Trailer			
55,000 pounds	4.44	3.52	1.26
80,000 pounds	5.54	15.74	0.35

SOURCE: Kenneth A. Small, Clifford Winston, and Carol A. Evans, *Road Work* (Washington, D.C.: Brookings Institution, 1989), Tables 3-4 and 3-5, pp. 45-46.

NOTE: The estimates shown here are based on current highway investment. Small, Winston, and Evans also provide estimates of marginal costs if investment levels were optimal.

a. Estimated marginal pavement cost under current investment.

b. A ratio of less than 1.0 indicates underpayment.

Table 4.
Estimates of Marginal Costs of Pavement (In 1982 cents per equivalent standard axle load mile)

Road Class	Marginal Costs: Brookings Institution	Marginal Costs: Federal Highway Administration
Rural Travel		
Principal Arterial		
Interstate	1.48	9
Other	4.38	21
Minor Arterial	10.02	a
Major Collector	16.49	28
Minor Collector	31.18	a
Local	101.3	50
Urban Travel		
Principal Arterial		
Interstate	2.38	25
Other freeways	4.32	66
Other	10.92	a
Minor Arterial	33.92	a
Collector	125.45	64
Local	40.92	80

SOURCES: Kenneth A. Small, Clifford Winston, and Carol A. Evans, *Road Work*, (Washington, D.C.: Brookings Institution, 1989), Table 3-3, p. 42; and Department of Transportation, Federal Highway Administration, *Final Report on the Federal Highway Cost Allocation Study* (May 1982), Appendix E, Table 3, p. E-25.

a. Numbers for arterials and collectors are not split into major and minor.

Interstate System, to $4.08 a mile for a four-axle truck with gross weight of 100,000 pounds on a road built for light traffic. The cost estimates of the *HCAS* are out of date now, but they illustrate well the principles involved in setting prices that reflect marginal costs. Of special interest is the fact that the weight supported by each axle is much more important than the total weight. That is, if truckers spread their loads over more axles, their vehicles would cause far less damage to pavements.[11] Charging according to axle weight is a way of providing an incentive to do this.

The authors of *Road Work* developed a similar pricing structure, shown in Table 6. The numbers differ somewhat from those of the *HCAS*, reflecting *Road Work's* conclusion that the relationship between axle weight and pavement damage is less acute than that used in the *HCAS*. The *Road Work* estimates show (reading across the rows of the table) how quickly the efficient level of charges increases as gross vehicle weight increases, for any given vehicle. They also show that spreading the weight over more axles (reading down the columns) reduces efficient charges for any given weight.

Revenues from Marginal Cost Pricing of Pavement. If marginal cost pricing could raise enough revenue to pay for pavement, it could serve as an efficient substitute for federal fuel and other taxes. Unfortunately, estimating revenues is difficult because the required information is scarce. Data are lacking on distances traveled by various vehicles on various kinds of highways. Technological advances that enable officials to weigh vehicles while they are moving and to identify them automatically will facilitate collection of this information.

Revenues also depend on how truckers would respond to being charged by axle weight. If many respond quickly by shifting to equipment with more axles, revenues would be lower than under the present configurations.[12] Traffic might increase as loads are spread over more vehicles and more axles. More loads might be carried by rail instead of by truck, especially where piggyback trucking is feasible.

The authors of *Road Work* conclude that "... efficient pricing of heavy vehicles would fail to recover the entire public cost even of the pavement, much less of the entire highway."[13]

11. Adding axles does not necessarily entail making the vehicle combination longer. Vehicle combinations are subject to restrictions on length. The question of the maximum safe length is beyond the scope of this study.

12. In this case, of course, costs would also be lower.

13. Small and others, *Road Work*, p. 93.

Table 5.
Efficient User Charges for Selected Vehicles and Operating Conditions
(In 1982 cents per vehicle-mile traveled)

Vehicle Type and Gross Weight	Location	Traffic Volume	Pavement Repair	Excess Delay	Air Pollution	Noise	Total[a]
Automobiles (3,000 pounds)	Rural	Light	b	0.3	b	b	0.6
Automobiles (3,000 pounds)	Urban	Heavy	b	11.2	1.5	0.1	13.5
3-Axle Single Unit Truck (60,000 pounds)	Urban collector or local	Moderate	180.0	3.1	4.0	8.0	259.6
4-Axle Truck-Trailer (100,000 pounds)	Rural arterial	Light	408.0	0.3	b	0.2	504.0
5-Axle Tractor-Semitrailer (72,000 pounds)	Rural interstate	Light	8.0	0.4	b	b	14.6
5-Axle Tractor-Semitrailer (72,000 pounds)	Urban interstate	Moderate	24.0	1.4	3.0	4.0	49.0
9-Axle Tractor-Semitrailer-Trailer (105,000 pounds)	Rural interstate	Light	5.0	1.2	b	0.1	10.3

SOURCE: Department of Transportation, Federal Highway Administration, *Final Report on the Federal Highway Cost Allocation Study* (May 1982), Appendix E, Table 12, pp. E-53 - E54.

a. Total includes administration costs and excess costs to road users associated with poor pavement quality.

b. Not estimated by Federal Highway Administration.

This is due to economies of scale in pavement construction and repair. But according to *Road Work*, combining congestion prices (which rise sharply as the number of vehicles increases) with marginal-cost pricing of pavement would generate more revenues than are currently raised by taxes on road users.

The *HCAS* Appendix E is more optimistic about the revenue-raising potential of efficient pavement charges. It estimates that revenues from efficient pavement damage charges would total $25 billion in 1981 dollars (and reflecting 1981 costs and conditions).[14] This is considerably more than the $6.5 billion that the federal government raised in taxes on highway users in 1981, although it falls short of the $40 billion spent on highways by all levels of government that year. When revenues from congestion pricing--estimated at nearly $54 billion--are added, however, revenues far outweigh spending.[15]

Feasibility of a Charge Based on Axle Weight and Mileage. The Federal Highway Administration has explored the feasibility of several ways of charging vehicles by weight and distance traveled.[16] In its study *The Feasibility of a National Weight-Distance Tax*, the FHWA concluded that a weight-distance tax "should be considered as a feasible alter-

14. Department of Transportation, *HCAS* Appendix E, Table 13, p. E-58.

15. Department of Transportation, *HCAS* Appendix E, Table 14, page E-59.

16. Department of Transportation, Federal Highway Administration (Highway Revenue Analysis Branch), *The Feasibility of a National Weight-Distance Tax*, Report of the Secretary of Transportation to the U.S. Congress Pursuant to Section 933 of the Deficit Reduction Act of 1984 (December 1988).

Table 6.
Marginal Costs of Pavement Maintenance for Current Traffic and Levels of Investment (In 1982 cents per vehicle-mile)

	Gross Vehicle Weight (Thousands of pounds)				
Vehicle Type	26	33	55	80	105
		Urban Travel			
Single Unit					
2-axle	9.16	23.77	183.38	a	a
3-axle	2.07	5.37	41.43	125.43	a
Truck-Trailer					
4-axle	a	a	23.67	105.94	314.39
5-axle	a	a	9.18	41.07	121.87
Tractor-Semitrailer					
3-axle	2.30	6.16	47.54	212.78	631.43
4-axle	a	2.93	22.61	101.19	300.30
5-axle	a	1.20	9.22	41.26	122.44
6-axle	a	0.71	5.45	24.42	72.45
Tractor-Semitrailer-Trailer					
5-axle	a	1.30	10.04	44.92	133.31
6-axle	a	0.81	6.22	27.83	82.58
		Intercity Travel			
Single Unit					
2-axle	3.21	8.33	64.26	a	a
3-axle	0.73	1.88	14.52	64.98	a
Truck-Trailer					
4-axle	a	a	8.29	37.13	110.18
5-axle	a	a	3.22	14.39	42.71
Tractor-Semitrailer					
3-axle	0.81	2.16	16.66	74.57	221.28
4-axle	a	1.03	7.92	35.46	105.24
5-axle	a	0.42	3.23	14.46	42.91
6-axle	a	0.25	1.91	8.56	25.39
Tractor-Semitrailer-Trailer					
5-axle	a	0.46	3.52	15.74	46.72
6-axle	a	0.28	2.18	9.75	28.94

SOURCE: Kenneth A. Small, Clifford Winston, and Carol A. Evans, *Road Work* (Washington, D.C.: Brookings Institution, 1989), Tables 3-4 and 3-5, pp. 45-46.

a. Not estimated.

native to existing nonfuel taxes."[17] The study found that administrative and compliance costs would depend on several factors. Taxing all vehicles weighing more than 26,000 pounds would be much more costly to administer than setting the threshold at 55,000 pounds. Basing the tax on registered axle weight instead of a vehicle's registered gross weight would impose greater costs for compliance on trucking companies. Evading a weight-distance tax would not be much (if any) easier than evading the present heavy vehicle use tax, since the distance traveled

17. Department of Transportation, *The Feasibility of a National Weight-Distance Tax*, p. xi.

could be cross-checked with current records of odometer readings and fuel use. The feasibility study reported that evasion of weight-distance taxes currently imposed by several states is apparently no more prevalent than evasion of the fuel tax.

The state of Oregon has used a weight-distance tax for nearly 45 years. The tax is based on registered gross vehicle weight and the number of miles traveled in Oregon. Vehicles weighing between 26,001 pounds and 80,000 pounds are classified in 2,000-pound increments, with higher tax rates for each increment. For example, a 28,000-pound truck would owe 4.45 cents per mile, while an 80,000-pound truck would owe 14.55 cents per mile. Vehicles heavier than 80,000 pounds are classified by number of axles as well as gross weight. For any given weight, the more axles, the lower the tax rate. As much as possible, this structure reflects the costs associated with vehicles of different weights. Oregon's weight-mile tax is its second largest source of highway revenues after fuel taxes. It brought in about $142 million in gross receipts in 1990, about 28 percent of the state's highway tax receipts.[18] The state estimates that truckers evade at most 5 percent of the weight-mile tax, a number that compares favorably with fuel tax compliance.

The Oregon experience suggests that weight-distance charges are feasible. Advances in technology, moreover, offer the promise of improving collection and enforcement. For instance, weigh-in-motion (WIM) technologies, which enable trucks to be weighed while moving at highway speeds, are becoming increasingly accurate. Several states now use WIM to monitor compliance with weight restrictions. Combining WIM and automatic vehicle identification would help officials collect weight-distance charges.

Distributional Considerations of Weight-Distance Charges. Charging on the basis of axle weight and distance would affect distribution. Heavily loaded trucks would pay more, and lightly loaded trucks or trucks spreading heavier weights over more axles would pay less. Over the long run, adjustments would be likely. As trucking companies replaced old equipment with new, they would be encouraged to increase the number of axles on their vehicles. Some heavy loads might be diverted from truck to rail.

The 1991 legislation expanded the ability of states to establish tolls on federally aided roads.

Congestion Costs

Congestion is another principal cause of the costs for using highways. As traffic increases, it reaches a point at which travel times tend to increase. When an additional vehicle enters a busy roadway it causes some motorists to slow down and adjust their spacing so that they are separated at a safe distance from the cars ahead. The more congested the road, the slower the traffic, until at some point it all grinds to a halt. The costs of delay rise steeply as congestion increases.

Factors Affecting Costs. Because congestion varies greatly over time and place, it is difficult to estimate the costs of congestion. Such an assessment requires making a number of assumptions about such key elements as average and marginal travel times, elasticity of demand, and value of time. For example, the *HCAS* Appendix E calculates the costs of delay, and the tolls that would be required to reduce traffic to the efficient amount (the

18. Department of Transportation, FHWA, *Highway Statistics 1990*, Tables MF-1, p. 74, and MV-2, p. 78.

amount at which the marginal social cost equals the marginal benefit), for urban highways not on the Interstate System. In very light traffic, time delays are relatively small, but they rise rapidly as the road gets more crowded. *HCAS's* 1982 estimates of charges to reflect time delays ranged from 0.23 cents per vehicle-mile for passenger cars to 16 cents as the volume of traffic neared the road's capacity.[19]

The costs of congestion could be better understood if more data were available about the number of miles traveled by different types of vehicles at different times of day. This information would help pinpoint who is contributing to congestion, with its attendant costs of delay and demands to build additional lanes or new roads. The effectiveness of a policy measure designed to alleviate congestion depends on the nature of demand for road use at peak times. If drivers could travel at other times, charging a peak-hour price might cause some to change the time they use the road, but if the demand for travel at a given time is inelastic, then other measures--such as lanes reserved for vehicles with more than one occupant--might be more effective. Their effectiveness, however, would involve a loss of economic efficiency.

Pricing to Reflect the Marginal Costs of Congestion. Congestion is an external cost. Each additional vehicle is not only delayed--its marginal private cost of congestion--but also delays other vehicles on the road. Because the marginal social cost is greater than the marginal private cost, drivers tend to use congested highways more than is efficient, since they choose the quantity at which demand equals marginal private cost; they would choose less if they had to bear the higher marginal social cost.

For many years, economists have advocated charging users of roadways at peak periods as a way of reducing congestion.[20] Although telephone companies have long used peak-load pricing for long-distance calls and electric utilities have more recently instituted the practice, it has been slower to catch on in transportation. Some transit systems, such as the Washington (D.C.) Metropolitan Area Transit Authority, charge higher fares at peak hours. But highway authorities have generally dealt with congestion through other means than pricing, such as restricting use of certain roadways or lanes to vehicles carrying more than one person. Section 1012(b) of the Intermodal Surface Transportation Efficiency Act of 1991 provides a stimulus for pricing based on congestion by establishing a program for pilot projects.

The *HCAS* Appendix E estimates the excess costs of delay for different types of vehicles operating in different kinds of locations on different types of roads (see Table 5). As one might expect, the costs of delay and their resulting efficient prices vary primarily according to whether the vehicle is operated in urban or rural areas; they are many times higher for urban than for rural travel. The differences between vehicle types in efficient charges based on congestion are relatively small, in contrast with efficient pavement charges.

After reviewing a number of studies of pricing for congestion in specific localities, Small, Winston, and Evans conclude that

> ". . . studies to date suggest that tolls on the order of $1.00 to $2.00 per round trip for typical congested commutes might reduce round-trip travel time by ten to fifteen minutes per commuter, raise revenues of tens of billions of dollars annually, and pro-

19. Department of Transportation, FHWA, *HCAS* Appendix E, Table 5, p. E-33.

20. For examples of early works on road pricing, see Herbert Mohring and Mitchell Harwitz, *Highway Benefits: An Analytical Framework* (Evanston, Ill.: Northwestern University Press, 1962); William Vickrey, "Pricing as a Tool in Coordination of Local Transportation," in *Transportation Economics* (New York: National Bureau of Economic Research, 1965), pp. 275-291; and A. A. Walters, "The Theory and Measurement of Private and Social Cost of Highway Congestion," *Econometrica*, vol. 29 (1961), pp. 676-699 (reprinted in *Transport*, Baltimore: Penguin Books, 1968).

vide some $5 billion in net benefits a year to society."[21]

Feasibility of Pricing Based on Congestion. Although congestion pricing has much in its favor as a theoretical principle, it presents practical problems: notably, setting the right price and collecting the charges.

Because efficient charges for congestion are related directly to location and time, determining the right price for all roads at all times becomes a mammoth undertaking. Selecting the roads on which to impose charges based on congestion and setting the schedule of fees by time of day may be a problem best left to state and local officials, who have more immediate and direct knowledge of specific local conditions than the federal government. But the federal government can suggest the conditions under which congestion charges might be most effective and can facilitate the flow of information about the experiences with alternative types of charges for congestion.

Any mention of tolls conjures up visions of interminable delays as long lines of vehicles queue up at toll booths. A solution to this problem is electronic sensing that identifies and charges vehicles automatically when they pass the toll-collection location.[22]

Electronic toll collection (ETC) is already in use on several highways. The Dallas North Tollway has used ETC for several years, and the Oklahoma Turnpike adopted it in 1991. Vehicles that regularly use the toll roads are equipped with transponders, small boxes about the size of credit cards, that are usually placed on the windshield. Users establish accounts and deposit toll prepayments in them. As the vehicles go through a toll booth, the toll is deducted automatically. The ETC systems use read-only technology. The monitor at the toll booth can read users' cards and deduct tolls. It works only at barrier tolls; it cannot keep track of where (or when) a vehicle enters and where it leaves a limited access highway.[23]

The Intermodal Surface Transportation Efficiency Act of 1991 authorizes a program for research in intelligent vehicle/highway systems which promises to provide better information about traffic flows on busy roads, identify vehicles using roads at congested times, and facilitate collection of tolls. Advances in IVHS would make it feasible to charge road users according to the time and location of use, and to do so without toll barriers or other impediments to the free flow of traffic.

The Federal Role in Congestion Pricing and Tolls. Until passage of the ISTEA, the federal government restricted states from imposing tolls on roads built with federal aid, with certain exceptions. In general, tolls were allowed only on highways that were toll roads before becoming part of the Interstate Highway System and on highways for which the states had repaid all federal aid.[24] When the Congress reauthorized the federal highway program in 1987, it established a pilot program allowing seven toll roads to be built or reconstructed with federal aid of up to 35 percent of the cost. The 1991 legislation expanded the ability of states to establish tolls on federally aided roads and raised the federal government's share to 50 percent. This development reflects a growing awareness of the useful purpose that tolls can serve in alleviating congestion and helping to finance additional road work.

Opponents of tolls often express concern that some states might establish toll policies designed to obtain most of their highway revenues from out-of-state vehicles passing through their jurisdiction. The federal gov-

21. Small and others, *Road Work*, p. 98.

22. Electronic toll collection can advance environmental objectives as well. It can reduce pollution at toll booths by maintaining traffic flow and thus avoiding the extra pollution emissions associated with stop-and-go traffic in queues.

23. More advanced read-write systems, which could keep track of entry and exit, are under development.

24. The exceptions are incorporated in Title 23, U.S. Code, Section 129.

ernment could help ensure that tolls were not discriminatory and did not impose undue burdens on interstate commerce.

Distributional Considerations. To be most effective, charges would be highest at the most congested times of day--the morning and evening commuting periods. They would affect all--rich and poor alike--commuting by automobile during those hours. If charges based on congestion were imposed, the working poor--or, more specifically, those working poor who drive to work at peak hours in downtown or other congested areas--would be hit with a rise in commuting costs. The size of congestion charges depends on how high they must be raised to induce some travelers to use mass transit, shift the time of their trips away from peak hours, change routes, carpool, or reduce the number of trips they take; whether mass transit is available; and whether employers offer subsidies (as many do) for parking.[25]

Defenders of congestion pricing point out that charging higher prices for peak-hour use than for off-peak use is common in the telephone and electric utility industries. In some cases, special provisions, such as rates for lifeline service, are made on behalf of poor consumers.[26] Any assessment of the burden of pricing based on congestion should take account of what is done with the revenues derived from it. If, for instance, revenues are used to improve mass transit, poor--and other--transit users will benefit. Proceeds from congestion charges could be used to reduce or eliminate other taxes or fees imposed on highway users, such as vehicle registration fees, which tend to be regressive.[27] If fuel taxes were reduced, rural drivers would benefit, as would operators of vehicles that get relatively few miles per gallon.

25. For an analysis of the effect of congestion pricing on the poor, see Kenneth A. Small, "The Incidence of Congestion Tolls on Urban Highways," *Journal of Urban Economics*, vol. 13 (January 1983), pp. 90-111.

26. A more general way of helping the poor--and one with fewer distortions--is to allow them refundable personal income tax credits.

27. Small and others, *Road Work*, p. 97.

Other External Costs Associated with Highway Use

For the sake of completeness, numerous other costs should be included in marginal social costs. Appendix E of *HCAS* contains discussions of these, including accident costs, air and water pollution, and noise, as well as estimates of their values. The marginal costs of these factors are small in relation to the costs of pavement damage and congestion.

The effects of traffic on noise and air pollution and their resulting costs are not as well understood than those of congestion. Research suggests that congestion worsens the pollution problem in areas that do not meet the national ambient air quality standards established by the Clean Air Act.

Charging for Other Externalities. Vehicles using gasoline and diesel fuel emit such air pollutants as oxides of carbon and nitrogen, hydrocarbons, volatile organic compounds, and particulate matter; they are also very noisy. To sensitize motorists to the social costs they are imposing and to induce them to cut back, charges could be imposed that reflect the cost of air and noise pollution. Authorities could charge for polluting in conjunction with charges for congestion, by means of automatic vehicle identification and scanning units. Because emissions and noise characteristics vary significantly by vehicle, pollution charges should vary by type of vehicle.[28] They also should vary by time of use, location, and ambient air quality.[29]

28. One Colorado study found that 10 percent of the automobiles passing a monitoring site emitted 50 percent of the pollution. See Donald H. Stedman, "Automobile Carbon Monoxide Emission," *Environmental Science and Technology*, vol. 23, no. 2 (1989), pp. 147-149.

29. Economist William Vickrey has suggested that vehicles be given a pollution rating at time of delivery, which would be adjusted over time. Charges could be varied according to vehicle rating, location of use, and weather conditions. On days when inversion or other adverse conditions threaten, increased pollution charges could be announced via news media and individuals would be given a strong incentive to postpone nonessential trips. Incentives would be offered to transfer vehicles with high emissions away from the most polluted areas.

As with congestion, the pricing theory is simple but applying it is difficult. Scientists disagree about the harmful effects of air pollutants on the environment and on the health of people who breathe polluted air. Similar disagreement exists on the damage noise causes. Estimates of the costs of pollution are therefore uncertain.

The *HCAS* Appendix E's estimates of efficient charges for air pollution and noise are shown in Table 5. The authors caution that these estimates are rough and rely on a number of simplifying assumptions. Of particular interest here is that they are small in relation to efficient charges for pavement damage and congestion.

What Should Be Done with Revenues from Pollution Charges? The economic rationale for air and noise pollution charges is that they would induce motorists to reduce their use of highways and the resulting social costs. It would therefore defeat the purpose of the charges for the proceeds to be earmarked for more highway spending, unless it was committed specifically to reducing social costs. Until 1990, motor fuel taxes were earmarked mostly for highways, with a small amount allocated to mass transit. The Omnibus Budget Reconciliation Act of 1990 set a precedent by allotting 2.5 cents a gallon to the general fund of the U.S. Treasury rather than the Highway Trust Fund. This option should be considered if pollution charges are imposed.

Other Considerations in Adopting New User Charges

To obtain efficient use of highways, users should pay a price equal to the marginal social cost of using them. Theoretically, pavement, congestion, and environmental charges could be designed to achieve this result. Moreover, technological advances are making it increasingly feasible to do so. The foregoing consideration of fuel and other existing federal taxes suggests that they do not measure up well against the efficiency criterion, since they do not closely reflect the marginal social cost of road use by various types of vehicles at various locations and times.[30] What, then, are the obstacles to moving from fuel taxes to pavement, congestion, and environmental charges?

Charges based on congestion costs send strong signals about the demand for new roads.

Gasoline and diesel fuel taxes are proven revenue raisers. Although estimates suggest that a combination of charges based on congestion, axle weight, and distance could raise as much or more revenue, they do not have a proven track record. Fuel taxes have been in existence for so long that they are well understood and generally accepted. Motorists find them more predictable than new types of charges with which they have had no experience.

The effects of taxes and charges imposed by the federal government cannot be evaluated without also considering state and local government policies. The benefits of efficient charges set by the federal government could be diluted or defeated by state policies that work at cross purposes.

This study has focused on pricing policies as a way to improve the productivity of the nation's roadways and the efficiency with which they are used. But many other federal policies

30. Fuel taxes would be suitable if they could be designed to reflect the social costs of pollution and energy consumption.

affect efficiency in highway use and design. Some of them could be reexamined if efficient pricing policies were imposed. For instance, many highway users complain that the roadways are not as durable as they should be. If highway users were charged explicitly for the pavement damage they cause, they would be motivated not only to reduce axle loads, but to argue vigorously for thicker, stronger pavements that would bear up better under heavy loads.[31] Small, Winston, and Evans estimate that if roadway investments, as well as prices, were at the optimal level, highway users would enjoy net benefits of $13 billion annually.[32] Given the demand signals sent by users' choices of load sizes, highway officials might reexamine existing design standards for highways and bridges, looking for more ways of obtaining greater net benefits from highway investments.

31. Thicker pavements are not necessarily a panacea. In some cases, construction techniques that allow better drainage or use materials less susceptible to freeze-and-thaw damage may be as effective in reducing life-cycle costs as adding another inch of pavement.

32. Small and others, *Road Work*, p. 7. The authors estimate that combining pavement charges and optimal investments in road durability could generate $8 billion in annual net benefits, and congestion charges could yield an additional $5 billion in net benefits. The estimates are in 1982 dollars.

Similarly, charges based on congestion costs send strong signals about the demand for new roads and additional lanes on existing roads. Congestion costs have implications for pavement durability, since delays caused by road maintenance would translate directly into higher congestion prices.

Conclusion

Existing federal taxes on highway users yield about the same amount of revenue as the federal government spends each year on highways. Alternative financing options are available, however, that could raise enough revenue to cover spending and promote greater efficiency in highway use. Charges for pavement that reflect the damage caused by heavy loads on each axle would encourage more efficient distribution of these loads and reduce the damage to roadways. Charges that reflect congestion costs would discourage nonessential travel on the busiest roads at the busiest hours and stretch existing capacity. Charges based on environmental costs would discourage travel that generates significant pollution and would probably measure up well against many of the alternative policies being considered to reduce pollution.

Chapter Three

Airways

The federal government provides numerous services to owners and operators of aircraft to ensure safe flights through the nation's airspace. In 1991, the Federal Aviation Administration (FAA) spent an estimated $4.8 billion on air traffic control and related services and on supporting facilities, equipment, research, engineering, and development.[1] Revenues from taxes on passenger tickets, international departures, cargo, and fuel generated about $4.9 billion in 1991.[2]

The air traffic control system has been under increasing pressure in the past decade. Airline traffic has burgeoned under deregulation and overwhelmed the capacity of increasingly antiquated equipment used for tracking and communicating with aircraft. The FAA forecasts that takeoffs and landings by major air carriers and regional airlines will increase from the current level of 22 million annually to almost 30 million by the year 2000.[3] The result could be delays caused by congestion when the airports and air traffic control are unable to handle demand at peak periods. Assuming that the demand for aviation services continues to grow at current rates and that capacity or new technology does not, by the year 2000 congestion and bad weather together will account for 20,000 hours or more of delay annually at each of the nation's 41 major airports.[4]

In 1981, the FAA embarked on a major investment program to replace outmoded air traffic control facilities and equipment. The object was to achieve more efficient use of the nation's airspace by 1991. This program, originally called the National Airspace System (NAS) Plan and now called the Capital Investment Plan (CIP), is expected to expand the capacity of the air traffic control system and alleviate delays. But until the new equipment is in operation, the air traffic control system will face increasing challenges in handling the rising volume of traffic.[5]

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1. Total FAA spending in fiscal year 1991 was $7.2 billion. The difference of $2.5 billion includes grants to airports and funding for aviation safety regulations, aviation security, and management programs.

2. Aviation excise taxes are levied on users in the private sector only. Public-sector users such as the military are not charged for using the air traffic system, although they contribute to its costs. These costs are covered by the general fund of the U.S. Treasury. In this chapter, unless otherwise noted, public-sector users are treated on an equal footing with other users so that the FAA costs referred to include both private- and public-sector costs.

3. Committee for the Study of Long-Term Airport Capacity Needs, *Aviation System Capacity*, Special Report 226 (Washington, D.C.: Transportation Research Board, National Research Council, 1990), Table 1-1.

4. Delays are based on the difference between the time that a flight would take if it did not have to wait at gates or runways and the actual flight time. Air traffic controllers make judgments about the cause of delay and report delays that exceed 15 minutes. Schedule delays that occur because of mechanical problems are not counted as delays. For more on the two ways in which the FAA measures delays, see Committee for the Study of Air Passenger Service and Safety Since Deregulation, *The Winds of Change*, Special Report 230 (Washington, D.C.: Transportation Research Board, National Research Council, 1991), pp. 210-215; and Department of Transportation, Federal Aviation Administration, *1990-91 Aviation System Capacity Plan*, DOT/FAA/SC-90-1 (September 1990), pp. 1-11 to 1-16.

5. The Capital Investment Plan is a continuing series of projects and does not have a single completion date. Several major components of the plan are scheduled for completion by the year 2000.

Congestion can be considered a shortage; it occurs when more services--of the air traffic control system or airport landing space--are demanded than can be supplied at a given time and place. When there is a shortage of a good or service, the economic solution is to raise the price. Charging a higher price forces users to reevaluate their demand, and only those who value the good or service enough to pay the price will continue to demand it. If aviation users were charged extra for peak-hour use, some would shift to less busy times, thereby alleviating congestion at the peak periods.

Some observers argue that aviation system users should cover the entire costs of the FAA.

Pricing can do more for efficiency than just alleviate congestion. Even when the airways are not congested, each flight imposes costs on the air traffic control system. If users recognize these costs and factor them into their operational decisions, the air traffic system as a whole can become more efficient. The prices that users are willing to pay for air traffic control services can also serve as signals indicating which additional investments will have the greatest payoffs. These signals can help the FAA set priorities in phasing in new equipment.

In response to perceived inadequacies in the air traffic control system, some observers have proposed privatizing it. Although examining the merits of privatization is beyond the scope of this study, the discussion in this chapter of alternative pricing mechanisms suggests some of the problems.

The proposals for privatization indicate how much the aviation system has advanced since the days when the federal government's policies were chiefly designed to promote air travel. The federal government continues to subsidize aviation from the general fund of the U.S. Treasury. Revenues from taxes imposed on aviation users over the past five years contributed about 60 percent of the FAA's total annual spending--including safety regulation and grants to airports--and 80 percent of estimated spending for air traffic control services. In light of the large federal budget deficit, there appears to be increasing sentiment for aviation users to pay the entire cost of the services they receive.

One argument in favor of continuing subsidies to aviation is that the safety of the aviation network can be considered a public good because even nonusers of planes face catastrophic consequences if there are accidents. It is difficult to charge users for the well-being of communities located below their flight path; therefore, a federal subsidy to help airlines and other users minimize the dangers to nonusers on the ground may be justified.

Background

The airway system, also called the air traffic control system, is designed to ensure the safe movement of aircraft through the nation's airspace. It includes traffic control at and between airports, weather advisories, and other services to help pilots plan their routes. Excluded from consideration in this study are federal aid to airports and such nontraffic-related FAA activities as certifying aircraft and pilots, setting safety standards, and other headquarters activities.

Why Are Airports Not Included?

Airports are not generally considered part of the air traffic control system. They are run by